MAGNT RESEARCH REPORT No. 11
JULY 2005

LAKE ALEXANDER: A BIOLOGICAL CENSUS

GEORGE W. PHILBEY AND RICHARD C. WILLAN

Museums and Art Galleries of the Northern Territory

Front cover. View of Lake Alexander from the outlet looking south. The area corresponds with the zone 1 from this study. Photo: G.W. Philbey, December 2003

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SUMMARY

An outbreak of the upside-down jellyfish *Cassiopea* sp. in 2002-2004 prompted a comprehensive qualitative and, for the molluscs and fishes, quantitative survey of Lake Alexander, a large artificial marine lake in Darwin, to assess which other species would be affected if measures were undertaken to eradicate the jellyfish. A total of 104 species of marine animals (including water birds and wading birds) was obtained. This total included 33 species of molluscs, of which one bivalve (*Tellina iridescens*) was a new record for Australia, another (*Particulazona milnei*) was only the second specimen known, and yet another (*Austrocochlea diminuta*) had not been recorded alive previously in the Northern Territory. This total included 21 species of polychaete (bristle) worms, of which *Hydroides sanctaecrucis* is the only non-indigenous species in the lake. This total included 11 species of fishes, but this number increased to 39 species when data from previous surveys conducted by the Darwin City Council and Museum and Art Gallery of the Northern Territory were incorporated. This present survey has shown that Lake Alexander possesses a diverse yet depauperate fauna. Invertebrate species with benthic crawling larvae are entirely absent. At present the ecosystem within the Lake is unique, but is more characteristic of a subtidal seagrass meadow than a mangrove forest.

KEYWORDS: faunal survey, biodiversity, *Cassiopea* sp., new species, *Tellina iridescens*, *Particulazona milnei*, *Austrocochlea diminuta*, Darwin, Northern Territory.

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GWP personal acknowledgments: My parents, Howard and Angela Philbey, assisted me in my sampling and supported and encouraged me in many other ways. This study was undertaken while I was a student at Palmerston High School and I thank the headmaster, Ms Sue Murphy, my Year 12 biology teacher, Mrs Shari Kundu, and Year 12 chemistry teacher and CSIRO-school liaison officer, Dr Amit Kundu, for academic encouragement and stimulating classwork. This study was also undertaken as part of the CSIRO Student Research Scheme by GWP for 2004.

LAKE ALEXANDER: A BIOLOGICAL CENSUS

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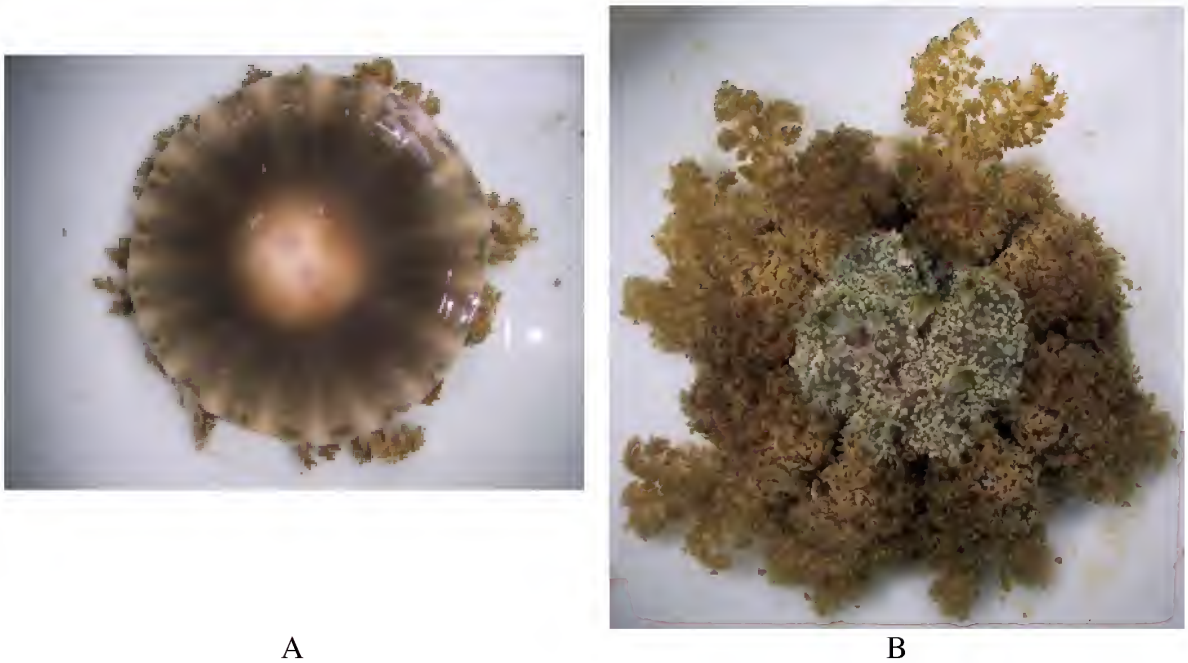
INTRODUCTION

Lake Alexander is a man-made lake that was constructed in 1991 as a recreational facility for the people of Darwin. Named after Alexander Fong-Lim, Lord Mayor of Darwin from 1984 to 1990, it is located at Fannie Bay, Darwin (12°24.80'S, 130°49.16'E). Its orientation is north/south with the outlet at the northern end (Front cover and Fig 2). It is an semi-enclosed marine system, approximately 450 m long and up to 250 m wide at the inlet (southern end). It is shallow at the margin with a maximum depth of 2.6 m in the centre. The lake has a natural clay base, with overlying sand deposits along the northern and western sides. Large rocks have been placed at the inlet and outlet, as well as the points on the eastern side. These stones were placed at these sites when the lake was built in order to prevent erosion.

According to officials from Darwin City Council there are not supposed to be any living organisms in Lake Alexander (R. Matthews pers. comm. January 2004). The sea water that is pumped into the lake from Fannie Bay is filtered through a fine mesh screen which is intended to stop larvae or propagules of organisms from entering the lake and thereby starting colonies (Kingsford and Gershwin 2003). Instead of there being no organisms in Lake Alexander, there is in fact a great variety of life, such as Crustacea (prawns and shrimps), Polychaeta (bristle worms), fishes, Mollusca (shellfish), birds, plant life (sea grass) and Porifera (sea sponges). Until now, there has never been a survey made of the lake's inhabitants (Kingsford and Gershwin 2003). There is no recreational fishing in the lake and never has been (Kingsford and Gershwin 2003).

Over the fourteen years that Lake Alexander has been open, it has been closed twice by the Darwin City Council on the grounds of public safety. First, was the occurrence of a large Estuary Rockcod (*Epinephelus coioides*). During 1998, this fish was biting unweary

swimmers. After several weeks of netting and setting traps, it was caught and removed from the lake along with many other species of fish, vouchers of which except for the Estuary Rockcod, now reside in the Museum and Art Gallery of the Northern Territory (H. Larson pers. comm. February 2004).



A B

Fig. 1. A, Aboral view of *Cassiopea* sp. (tentacles down) **B,** Oral view of *Cassiopea* sp. (tentacles upwards).

The second and more serious incident causing the lake to be closed was the appearance of the jellyfish *Cassiopea* sp. (Fig. 1) (commonly known as the upside-down jellyfish) during late 2002, throughout 2003, and for the first two months of 2004. Bowing to public concern, the Darwin City Council decided in 2003 to eradicate the jellyfish. This jellyfish, which is apparently an undescribed species (Kingsford and Gershwin 2003; Holland *et al.* 2004), causes painful and lasting stings on contact with the skin. In addition, it secretes a mucus cloud impregnated with microscopic stinging cells (nematocysts) which can also cause mild irritation. Normally an adult can touch one of these jellyfish with little problem as the nematocyst threads, when discharged, cannot penetrate thick skin (but soft skin such as that on the stomach and inner arms is vulnerable to stings). Children are more susceptible to the stings than adults.

There has never been such a detailed survey of the benthic invertebrates and fishes living in Lake Alexander. This study, conducted intensively over a three month period but actually spanning December 2003 to May 2005, was intended to characterise the community and ecosystem type of the lake. Quantitative and qualitative baseline data collected during this survey can be used for management purposes, as for example, another outbreak of *Cassiopea* sp.

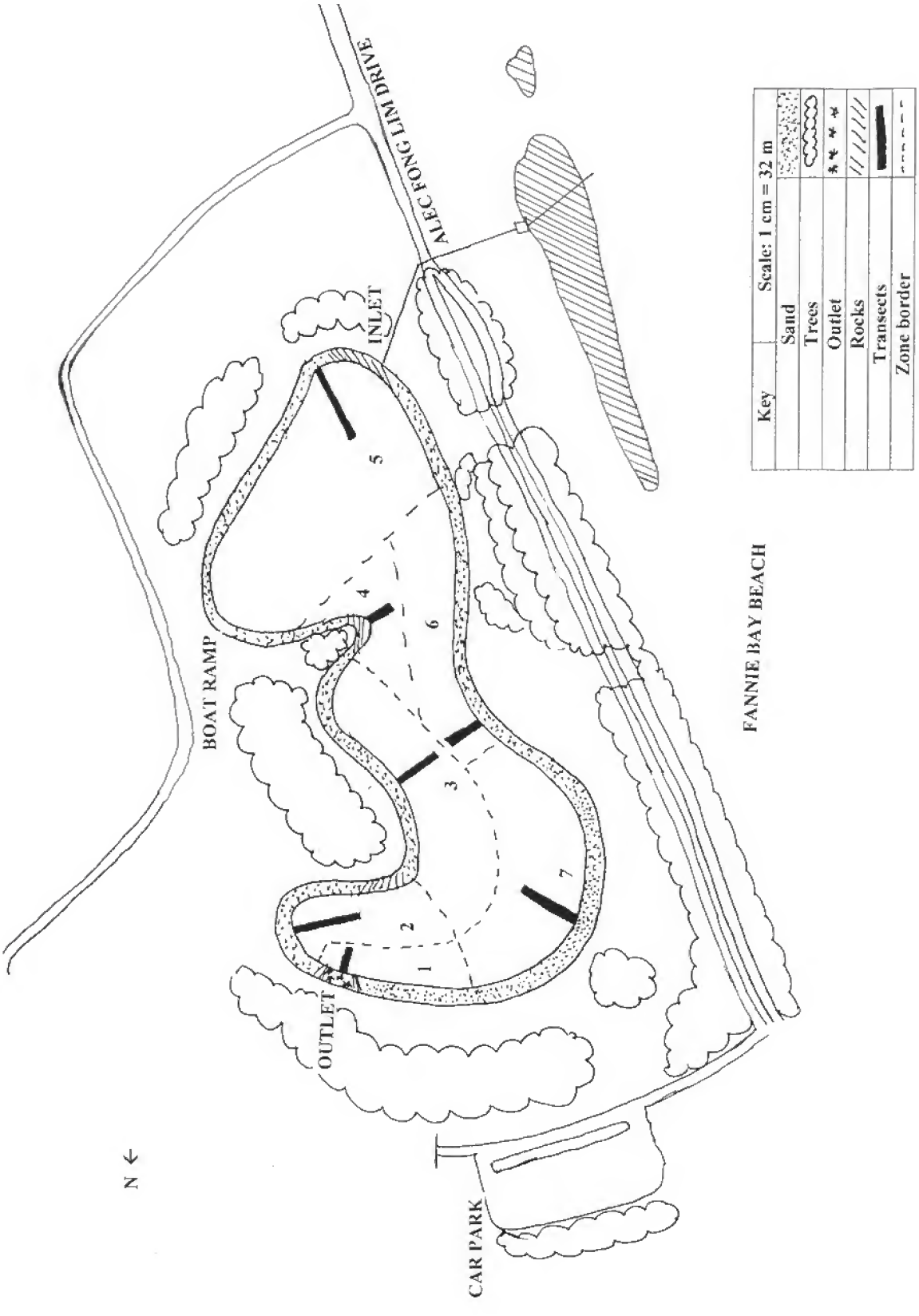


Fig. 2. Lake Alexander map showing zones used for this survey and location of transects within zones.

METHODS

A system of stratified random sampling was employed during our survey of the lake in order to include all substrate and habitat types. The lake was divided into seven areas that we have termed "zones" (Fig. 2), roughly equivalent to the ten areas designated in the survey by Kingsford and Gershwin (2003). We determined that several of the areas surveyed by these authors contained the same habitat type, and therefore could be pooled.

Zone 1 had a fine muddy substrate in shallow water with little seagrass (*Halodule pinnifolia*). Zone 2 consisted of anoxic mud and abundant seagrass. Zone 3 consisted of sand, gravel and mud with scattered seagrass. Zone 4 consisted of large boulders embedded in a sandy clay substrate. Zone 5 is similar to zone 4, but the substrate contained much more gravel with sparse seagrass. Zone 6 consisted of relatively clean sand with copious seagrass. Zone 7 consisted of sand with gravel and no seagrass. All the zones had a similar muddy substrate below 1.5 m.

Between December 2003 and May 2005, these zones were surveyed qualitatively for living organisms, particularly molluscs. During these qualitative surveys, living organisms were sampled using either a benthic sampler, hand seine, beach seine, dip net, hand line or by visual searching. Between March and May 2004, all the zones were surveyed quantitatively for living invertebrates and on 8 April 2004 the fishes were surveyed quantitatively. During these surveys, invertebrate specimens were collected using a pipe sampler (Fig. 3). All zones, excluding 2 and 6, had four sample sites. Labelled 1 through 4, these were at the water's edge (0 m), 0.5 m, 1.0 m and 2.0 m, respectively. Zone 2 did not have a 2.0 m sample as it intersected with zone 1 at this depth. Zone 6 had an extra sample taken at 2.6 m, because this is the deepest point in the lake.

Fig. 3. The pipe sampler used during this survey for quantitative benthic sampling.

Invertebrates were sampled using a hand made pipe sampler. This consisted of a length of plastic electrical conduit 10 cm in diameter, which was driven 15 cm into the substrate of the lake thus retrieving a sample of approximately 1178 cm^3 (1.2 L) in volume. This is an

average calculation of the samples taken per zone, as the samples taken at the water's edge would not have been any greater than 10 cm in depth. Samples were then sieved on site, the washings placed in separate plastic bags, tagged, and then preserved in 70% ethanol solution (except for the polychaetes that were first fixed in 10% formalin). A physical search was conducted simultaneously at each zone and specimens not recovered by the pipe sampler were collected.

During both the qualitative and quantitative surveys, empty shells of two species of molluscs not living in the lake were discovered. The shell of the moon snail *Natica colliei* was probably accidentally incorporated with clean beach sand when it was brought in to make the sandy beach in 1991. The shell of the freshwater mussel *Velesunio* sp. must have been brought to the lake by a human.

During the quantitative survey for fishes, samples were obtained using a beach seine, hand seine, dip net and hand line. The beach seine was dragged along each of the seven zones. A hand seine was also used at each zone to sample the smaller benthic fishes such as gobies. Baited fish pots were placed at both the two eastern rocky outcrops in zones 4 and between zones 2 and 3. The dip net and hand line were used at zone 1. A subsample of the fishes captured was euthanased by placement in ice-cold water and then transfered into an esky full of ice.

The list of birds recorded in Table 4 are those that are exclusively dependent on the lake's ecosystem for feeding, such as wading and water birds. Many other birds, like honeyeaters, peewees and, in the Dry season, black kites can be seen around the lake, but they have no dependence on it and so they are not included. On one occasion we observed a pair of Burdekin ducks at the lake edge, but they were only transitory.

Vouchers of all molluscs, polychaetes, crustaceans and fishes recorded during this census are deposited in the Museum and Art Gallery of the Northern Territory (MAGNT) for future reference. A sample of the mollusc *Austrocochlea diminuta* was preserved in absolute ethanol for studies at the University of Otago on the phylogenetic relationships of monodontine trochids (Donald *et al.* in press).

RESULTS

Tables 1-4 list all the organisms recorded during the qualitative surveys. Appendices 1-3 give data for molluscs taken the three months during which our quantitative surveys were undertaken. Appendix 4 gives these data for the fishes.

The Biological Community in Lake Alexander: composition

A total of 104 species of strictly marine animals (and water birds, as explained above) were recorded from the lake during all the surveys. They yielded 75 previously unrecorded species. By any count this number comprises a remarkably rich marine community living in the lake. This community consists of 11 fish species (Table 1), 33 mollusc species (Table 2), 20 polychaete (bristle worm) species (Table 3) and 11 other invertebrate and vertebrate species (Table 4). Table 1 represents pooled data from three different sources over a period of six years, so some species may be not be living in the lake any more. Not

all of the fish species listed in Table 1 were actually seen during our survey (i.e., barramundi) because 28 species were recorded on earlier surveys but not recollected on our survey. Not all of the polychaetes listed in Table 3 were actually seen during our survey because we never found *Hydroides* sp.

Major habitats and dominant species in these habitats

In total there are four major habitat types within the lake: sand, mud, seagrass, and rocks. *Halodule pinifolia* is the only species of seagrass in the lake. Compared to other seagrasses, *H. pinifolia* is recognised by its small leaf blade size, delicate appearance, thin linear leaves, more or less rounded leaf tip, often with the central vein splitting in two at the apex.

There is some overlap between the soft bottom habitat types in the zones we have defined. For example zones 2 and 6 appear to be areas where such an overlap occurs. Zone 2 has characteristics of a sandy substrate as well as being very muddy and anoxic. Zone 6 has characteristics of sand, clay, mud and seagrass.

Each of the zones we defined according to its substrate type has characteristic animals. For instance, *Cerithium coralium* is characteristic of mud and seagrass, both at the water's edge and in deeper water (up to 2 m deep). *Cerithideopsilla cingulata* is abundant on both sandy and muddy substrates with or without seagrass from 0 to 1 m in depth. *Circe australis* is the most common and ubiquitous bivalve in the lake, occurring on both sandy and muddy substrates from 0 to 2 m in depth. *Chama fibula* was found to only inhabit zone 1 on the concrete outlet. Two species of micromollusc were exclusive inhabitants of the seagrass – *Diala* sp. and *Stenothyra* sp.

Monthly quantitative surveys

The results of these surveys are presented in Appendices 1-4. The samples taken from zones 1 and 2 in March were not analysed because they were taken from the wrong water depth. The maximum number of molluscan species occurring live in a single sample was 12 at zone 1.2 in May and this corresponded with a total of 240 individuals at this zone. Maximum diversity for fishes (3 species) was shared between zone 1 (7 individuals), zone 2 (84 individuals) and zone 3 (8 individuals). No molluscs at all were found to be living in zones 4.1, 4.4, 5.1 and 5.4 (March), zones 4.1, 4.4, 5.1 and 6.5 (April), and zones 1.4, 4.4, 5.1, 6.3 and 6.5 (May).

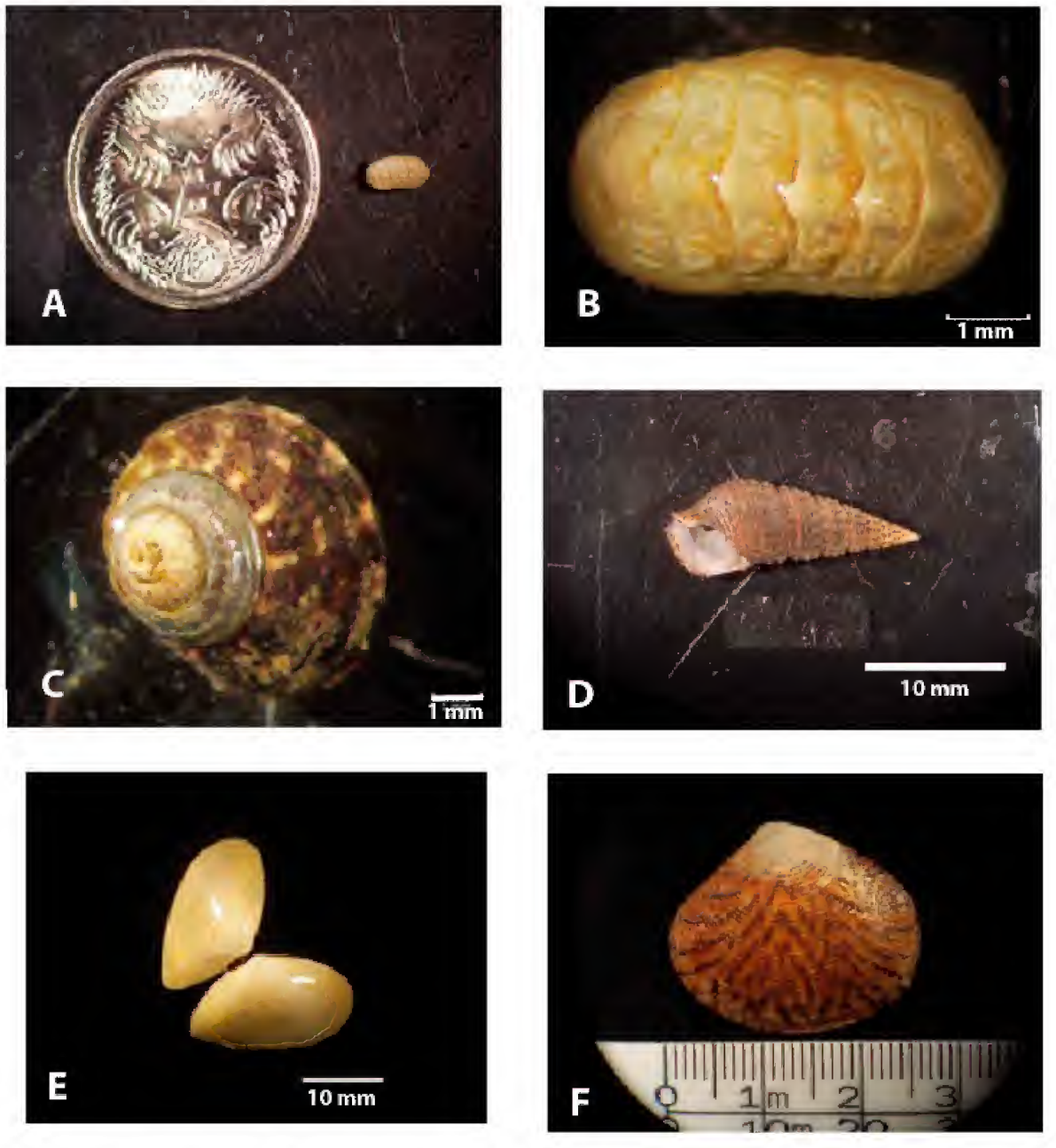


Fig. 4. Molluscs inhabiting Lake Alexander. A, B. *Particulazona milnei*; C. *Austrocochlea diminuta*; D. *Cerithium coralium*; E. *Tellina iridescens*; F. *Circe australis*.

Significant discoveries from this census

Particulazona milnei Kaas, 1993 (Fig. 4A,B) is a very small (only 5 mm long) chiton of the family Leptochitonidae that was only known previously from one specimen, the holotype, collected in mangrove forest at Frances Bay, so the specimen from Lake Alexander is only the second known of this very rare species. It was sorted out from the quantitative sample taken at zone 1.1 in April. Its identity was first established by RCW and later confirmed by K.L. Gowlett-Holmes. It is deposited in the wet mollusc collection at the MAGNT with the registration number P26761. *Particulazona milnei* is characterised by its peculiar girdle covering consisting of minute, crowded, spiculose calcareous

corpuscles (Kaas 1993), and to date there are no other species in the genus *Particulazona* which, along with another ischnnochitonid genus *Subterenochiton*, is endemic to Australia (Cochran 1998; Gowlett-Holmes 2001).

Austrocochlea diminuta Hedley, 1912 (Fig. 4C). This is the first time this small, monodontine top shell species has been found alive in the Northern Territory. Being so small and the only northern Australian representative of a numerically large southern Australian genus, it is somewhat of an enigma. For example, Wilson (1993) overlooked it in his comprehensive book on Australian prosobranch gastropods. However, Jansen (1996) mentioned its presence in northern Queensland with the comment: "Very common on intertidal stones in sheltered bays" and this statement is essentially true for the population in Lake Alexander, but there it lives on coarse sand more than stones. It is approximately 6 mm in length and bears 6-8 strong axial flames, usually dark in colour, on the spirally ribbed shell.

Tellina iridescens Benson in Cantor, 1842 (Fig. 4E). This is the first record of this species being found alive in Australia. Despite it not being included in either of the recent books on Australian bivalves (Lamprell and Whitehead 1992; Lamprell and Healy 1998) it is cited as occurring in northern Australia by Koga *et al.* (2003). The original identification of specimens from Lake Alexander were by RCW and a subsequent close examination of small tellinids in the mollusc collection of MAGNT revealed specimens from five locations across northern Australia: Roebuck Bay; Bynoe Harbour; Darwin Harbour; Arnhem Land; Melville Bay (RCW pers. obs.). *Tellina iridescens* is included (as *Moerella iridescens*) in the most recent major book on Japanese molluscs (Matsukuma 2000), however Koga *et al.* (2003) corrected the habitat given for it there of "fine sand bottom in embayment within 20 m deep" to "from the upper to lower intertidal zones but not in the subtidal zone or deeper". Japanese Red Data books list this species as "vulnerable" throughout Japan and it is endangered in the Tagori River (Koga *et al.* 2003). *Tellina iridescens* is common in seagrass beds at Lake Alexander from 0 m to 2 m with the largest specimen being approximately 20 mm long.

Biological notes on molluscan species (families are given in Table 1). The following 33 species are arranged in alphabetical order by genus.

Atys subtortuosus Schepman, 1913
Occurrence: Dead shells of this gastropod were found at zone 3, during all three monthly quantitative surveys. This species has been included in the mollusc list as the shell is too fragile to have been imported intact with the beach sand in 1991, and the sampling methods used were not accurate enough to collect a live specimen.

Austrocochlea diminuta Hedley, 1912 (Fig. 4C)
Occurrence: See above for an account of this gastropod.

Booneostrea cucullina (Deshayes, 1836)
Occurrence: Specimens of this oyster were sighted at all rocky locations during the entire survey. This white oyster attaches to the undersurface of stones in shallow water. The distribution of this species within the lake appears to be quite sparse.

Brachidontes maritimus (Pilsbry, 1921)
Occurrence: Specimens of this bivalve were found at zone 1, to a depth of approximately 0.3 m during the May quantitative survey. Specimens were found to be attached to the encrusting organisms on the concrete walls and base of the outlet.

Calthalotia mundula (A. Adams & Angas, 1864)
Occurrence: Specimens of this gastropod were found at zones 1, 3, 6 and 7, during all three monthly quantitative surveys.

Cerithideopsilla cingulata (Gmelin, 1791)
Occurrence: Specimens of this gastropod were found at all zones, during all three monthly quantitative surveys. This species has been found at all sampling sections except for eight out of the 27 sites. This appears to be the second most common species of gastropod in the lake.

Cerithium coralium Kiener, 1841 (Fig. 4D)
Occurrence: This species of gastropod occurs at all zones (including all soft habitats) and it is the most common species of gastropod found in Lake Alexander. It was located from 0 to 2 m in depth, during all three monthly quantitative surveys.

Chama fibula Reeve, 1846
Occurrence: This bivalve was found only at zone 1, during the April and May quantitative surveys. *Chama fibula* attaches to hard surfaces such as rocks and concrete. It appears that it prefers flowing water as it was only found at the site of the outlet. This species was only found between 0.05 and 0.3 m in depth.

Circe australis (G. B. Sowerby I, 1851) (Fig. 4F)
Occurrence: Specimens of this bivalve were found at all zones, during all three monthly quantitative surveys. This is the most common species of bivalve and most ubiquitous species of mollusc in Lake Alexander.

Clypeomorus bifasciata (G.B. Sowerby II, 1885)
Occurrence: Only one dead adult shell (15 mm long) of this gastropod was found at zone 4 during the March quantitative survey.

Diala sp.
Occurrence: Specimens of this microscopic gastropod were found at zones 3 and 6. This species was only found on seagrass. It was not until after the three surveys that this species was found as the sampling technique used, lost the specimens during the sieving process. These specimens were taken using a small dip net, during a qualitative survey.

Gafrarium tumidum Röding, 1851
Occurrence: Specimens of this bivalve were found at zones 1, 4, 5 and 6, during all three monthly quantitative surveys. It is certainly gathered from the lake for human consumption in a recreational context, but never as a commercial enterprise.

Glauconome plankta (Iredale, 1936)
Occurrence: Only one specimen of this bivalve was recovered from the lake. It came from zone 4 during the March quantitative survey. Although this shell was freshly dead, both valves were intact with the hinge still in one piece, and this indicated that it must have been living in the lake shortly before it was collected.

Isognomon nucleus (Lamarck, 1819)
Occurrence: Only one specimen of this bivalve was found in Lake Alexander. It was living among stones at the outlet in May 2005.

Marcia hiantina (Lamarck, 1818)
Occurrence: Specimens of this bivalve were found at zones 1 and 2 during the May quantitative survey.

Mitrella essingtonensis (Reeve, 1859)
Occurrence: Specimens of this small gastropod were found at zones 3, 6 and 7. No live specimens were obtained using the pipe sampler in zones 3 and 6. Specimens were sighted during all three monthly surveys and collected during the March and May quantitative surveys. This species is carnivorous, however it could also be classed as a scavenger, as it was noticed eating bread tossed into the lake at zone 3 during the March quantitative survey.

Musculus miranda (E.A. Smith, 1873)
Occurrence: Only one dead shell of this small bivalve was found at zone 4, during the March quantitative survey. This species was included in the mollusc list as the shell is too fragile to have been imported intact with the beach sand in 1991.

Nassarius dorsatus (Röding, 1798)
Occurrence: This gastropod was sighted at zone 3 up to 25 mm long. Specimens were recorded during all three monthly quantitative surveys. This species appears to occur mainly in areas of sandy substrate with seagrass covering seventy percent or more of the substrate.

Nassarius fraudator Cernohorsky, 1980
Occurrence: Two freshly dead shells of this gastropod were found; one in June 1999 and the other at zone 3 during the March qualitative survey. It was collected in the same area as *Nassarius dorsatus*.

Particulazona milnei Kaas, 1993 (Figs 4A,B)
Occurrence: See above for an account of this chiton.

Patelloida cryptalirata (Macpherson, 1995)
Occurrence: Only one specimen of this gastropod was found at the northern rocky outcrop during a qualitative survey in late December 2003. It was found attached to the outside of a *Terebralia palustris* shell.

Pitar inconstans (Hedley, 1923)
Occurrence: Specimens of this bivalve were found at zones 1, 3, 6 and 7 during all three monthly quantitative surveys.

Pugilina cochlidium (Linné, 1758)
Occurrence: One dead adult shell (80 mm long) of this gastropod was found at zone 5 during the May qualitative survey, however its distinctive egg masses were seen from the middle of the south bank approximately 50 m north of zone 5 on all three of the months of the quantitative surveys.

Serracorbula coxi (Pilsbry, 1897)
Occurrence: Specimens of this bivalve were found at zones 1, 3, 4 and 6. No live specimens were taken using the pipe sampler at zones 1, 4 and 6. Live specimens were sighted during all three monthly surveys, and collected during the April quantitative survey.

Stenothyra sp.
Occurrence: Specimens of this microscopic gastropod were found at zones 3 and 6. This species was only found on seagrass. It was not until after the three surveys that this species was found as the sampling technique used, lost the specimens during the sieving process. These specimens were taken using a small dip net, during a qualitative survey.

Telescopium telescopium (Linné, 1758)
Occurrence: Only five specimens of this gastropod were found live at zone 1 at a depth of 0.25 m during the May quantitative survey. Its absence during all the qualitative surveys suggests its occurrence is very sporadic and may be imported by humans.

Tellina capsoides (Lamarck, 1818)
Occurrence: Specimens of this bivalve were sighted at zone 2, 6, and 7, during the April and May quantitative surveys. Only one was ever recovered in the benthic samples.

Tellina iridescens Benson in Cantor, 1842 (Fig. 4E)
Occurrence: See above for an account of this bivalve.

Terebralia palustris (Linné, 1767)
Occurrence: One specimen of this gastropod was sighted at zone 1 at a depth of <0.10 m, during the April quantitative survey. Many fragments of dead shells were noticed on the sandy and grassy embankments above the lake all through this survey indicating collection for consumption by humans in a recreational context.

Terebralia semistriata (Mörch, 1852)
Occurrence: Four specimens of this gastropod were sighted at zones 4 and 5, during January 2005, two of which were live and the other two freshly dead.

Tornatina sp.
Occurrence: Seven specimens of this small gastropod were found at zone 3, during the March qualitative survey. The circumstances surrounding this species are the same as with

Atys subtortuosus and it is for the same reason that *Tornatina sp.* has been included in the mollusc list.

Trapezium sublaevigatum (Lamarck, 1819)
Occurrence: Specimens of this bivalve were found at zone 1, during the April and May quantitative surveys. They only occurred as part of the encrusting organisms on the concrete wall of the outlet to the lake.

Venerupis irus (Linné, 1758)
Occurrence: Specimens of this nestling bivalve were taken at zone 1 during the May quantitative survey.

***Cassiopea* sp. data**
From the beginning of the survey (March 2004) to the time of writing (July 2005) there has only been one occasion on which the presence of the jellyfish *Cassiopea* sp. was noted. For a brief period in September 2004 staff of Darwin City Council sighted *Cassiopea* sp. When one of us (GWP) inspected the lake during this time, only one juvenile could be located at zone 4. Since the last outbreak of *Cassiopea* sp. in 2004, Darwin City Council now pumps fresh water into the lake as soon as any *Cassiopea* sp. is detected to prevent further outbreaks (D. Perry pers. comm. April 2005).

Note on polychaetes
Polychaetes were sampled during June 2005, and 20 species were found then. Of these species, some have been previously collected in the lake by Chris Glasby in 2000 including an unidentified species of serpulid, *Hydroides* sp., which appeared to be absent in the June 2005 survey. Interestingly, *Hydroides sanctaecrucis*, a non-indigenous species in Darwin Harbour, which occurs on rocks at zones 1, 2, 4 and 5, was absent in 2000. In 2000 *Pomatoleios* sp. was the dominant serpulid in the lake, but in June 2005 the introduced *Hydroides sanctaecrucis* was dominant.

DISCUSSION & CONCLUSIONS

During this first biological census conducted on Lake Alexander, three marvels were encountered in the samples taken — the chiton *Particulazona milnei*, the bivalve *Tellina iridescens* and the gastropod *Austrocochlea diminuta*. The sampling techniques used were not comprehensive enough to yield a complete list of everything in the lake, especially the meiofauna. The results gathered from these sampling techniques are enough to construct a relatively complete species list. However it is plausible to conclude from the results gathered that at present this is indeed a unique ecosystem. It is unique in the fact that species are unexpectedly present (for example *Particulazona milnei*). Despite the proximity of the mangrove-lined Ludmilla Creek only 1 km to the north, the obligate mangrove taxa are absent from Lake Alexander or present in very low densities. Significant mangrove molluscs that we never encountered in Lake Alexander are the following: *Terebralia semistriata, Littoraria filosa, L. articulata, Nerita balteata, Neritina violacea, Assiminea sp., Cerithidea obtusa, Chicoreus capucinus, Thais trigonus, Melanoides tuberculatus, Iravadia quadrasi, Pseudanachis duclosianus, Haminoea sp., Onchidium* (6 spp.), *Ellobiidae* (18 spp.), *Booneostrea cucullina, Isognomon ephippium, Musculista cf. japonica, Anodontia edentula, Enigmonia enigmatica, Austriella corrugata,*

Azorinus minutus, Gari togata, Polymesoda erosa, Laternula spp., *Entodesma sp* and *Bactronophorus thoracites*. Similarly, some fishes characteristic of mangrove communities in Darwin Harbour that have never been recorded during any survey from Lake Alexander are: *Periophthalmus* (6 spp.), *Marilyna darwini*, *M. meraukensis* and *Chelonodon patoca* (R. Williams pers. comm.). Such notable absences, plus the fact that Lake Alexander is nowhere lined with mangroves indicates this particular lake cannot be characterised as a body of water in part of a mangrove system, though one would expect it to be so from its sheltered position close to Fannie Bay and low lying elevation. And neither could Lake Alexander be characterised as a lake in the hinterland margin immediately behind a mangrove forest because such lakes are very shallow and hypersaline, and dry out completely during the dry season (K. Metcalfe pers. comm.).

In fact Lake Alexander is a seagrass ecosystem, owing to the predominance of the seagrass *Halodule pinifolia*. This seagrass is a fast-growing, (usually) ephemeral, tropical species (M. Campey pers. comm.). It reproduces from seed banks with rapid reseeding. There is high plant turnover with a rapid response to perturbation. *Halodule pinifolia* is one of the preferred food sources for dugong and turtles (M. Campey pers. comm.). We know that two of the micromolluscs encountered on this survey, *Diala* sp. and *Stenothyra* sp., are seagrass obligates. Recent surveys of seagrass communities in shallow coastal regions in Arnhem Land by MAGNT staff have revealed a generally similar species composition to Lake Alexander. For example, these surveys revealed the numerical dominance of the molluscs *Cerithium coralium*, *Cerithideopsilla cingulata, Calthalotia mundula, Nassarius dorsatus*, *Mitrella essingtonensis*, *Circe australis* and *Pitar inconstans*, all of which are very common in Lake Alexander. Seagrass meadows are rare in Darwin Harbour, and Lake Alexander is certainly the most accessible to the public, so Lake Alexander has a biological significance far beyond its recreational importance.

Suggestions for the total eradication of *Cassiopea* sp. are limited due to the diversity of the marine fauna of Lake Alexander. Actions by the Darwin City Council in flooding the surface waters with fresh water certainly thwarted the outbreak of *Cassiopea* sp. in 2004, and at the time of writing there are no polyps of *Cassiopea* sp. visible in the lake (but the microscopic hydroid phase could be alive on the rocks). If *Cassiopea* sp. reappeared and any more drastic actions were taken to eradicate it the effects could be detrimental to the seagrass and the entire biological community that it supports. Possible impacts on the biota in the lake could include a dramatic decline in species diversity, if not total eradication. There are over 104 water dwelling species inhabiting the lake, excluding water birds and plants. Included in these species are three molluscs that would be highly unfortunate to lose as they are so unique (*Particulazona milnei*, *Austrocochlea diminuta* and *Tellina iridescens*). It is because of the tremendous losses that could occur, that we recommend any methods chosen to eradicate *Cassiopea* sp., take into account the high biodiversity of the lake before any plan is put into action.

We recommend that a yearly survey should be undertaken to check for the presence of *Cassiopea* sp. and other fauna because it is certain their presence and abundance will fluctuate within this small, seagrass-dominated ecosystem.

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Table 1. List of fishes (Vertebrata: Pisces) from Lake Alexander			
(Species marked with an asterisk were recorded during the present survey)			
Family	**Scientific Name**	**Common Name**	**MAGNT Voucher**
Ambassidae	* *Ambassis nalua*	Scalloped Glassfish	S15878-013
Ambassidae	* *Ambassis vachellii*	Vachell's Glassfish	S15787-015
Carangidae	*Caranx sexfasciatus*	Bigeye Trevally	
Centropomidae	*Lates calcarifer*	Barramundi	
Clupeidae	* *Herklotsichthys gotoi*	Darwin Herring	S15878-006
Clupeidae	* *Herklotsichthys lippa*	Small-spotted Herring	S15878-007
Clupeidae	*Nematolosa come*	Bony Bream	S15036-001
Clupeidae	* *Sardinella brachysoma*	Deep-bodied Sardine	S15036-002
Engraulidae	*Thryssa* sp.	Anchovy	
Engraulidae	*Thryssa hamiltoni*	Hamilton's Thryssa	S15036-003
Ephippidae	*Drepane punctata*	Sicklefish	
Gerreidae	*Gerres erythrourus*	Silverbiddy	S15036-007
Gerreidae	*Gerres* sp.	Silverbiddy	
Gobiidae	* *Acentrogobius janthinopterus*	Robust Mangrove-goby	
Gobiidae	* *Cryptocentroides insignis*	Insignia Goby	S15878-004
Gobiidae	* *Drombus globiceps*	Kranji Drombus	S15878-016
Gobiidae	*Pseudogobius poicilosomus*	Northern Fatnose-goby	
Gobiidae	* *Pseudogobius* sp.	Fatnose-goby	S15878-011
Hemirhamphidae	*Arrhampus sclerolepis*	Snub-nosed Garfish	S15036-006
Leiognathidae	*Leiognathus blochii*	Two-blotch Ponyfish	S15036-011
Leiognathidae	*Leiognathus decorus*	Ornate Ponyfish	S15036-010
Leiognathidae	*Leiognathus* sp.	Ponyfish	
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove Jack	
Megalopidae	*Megalops cyprinoides*	Oxeye Herring	
Mugilidae	*Liza ordensis*	Flathead Mullet	S15036-016
Mugilidae	*Liza vaigiensis*	Diamondscale Mullet	
Mugilidae	?	Silverback Mullet	
Mugilidae	?	Trumpeter Mullet	
Mugilidae	?	Poddy Mullet	
Polynemidae	?	Salmon	
Scatophagidae	*Scatophagus argus*	Spotted Scat	
Scatophagidae	*Selenotoca multifasciata*	Striped Scat	
Serranidae	*Epinephelus coioides*	Estuary Rockcod	
Sillaginidae	* *Sillago burrus*	Western Trumpeter Whiting	S15036-009
Sillaginidae	*Sillago sihama*	Morthern Whiting	S15036-008
Teraponidae	*Terapon jarbua*	Crescent Grunter	
Tetraodontidae	?	Puffer Fish	
Tetraodontidae	?	Toad Fish	
Tetraodontidae	* *Amniataba caudavittata*	Yellow-tail Grunter	S15036-005

Table 2. List of molluscs (Mollusca: Polyplacophora, Gastropoda and Bivalvia) from Lake Alexander

(All the species in this table were recorded during the present survey)

Family	Scientific Name	Common Name	MAGNT Voucher
Buccinidae	*Pugilina cochlidium*	Spiral Melongena	
Cerithiidae	*Cerithium coralium*	Coral Creeper	P16334
Cerithiidae	*Clypeomorus bifasciata*	Necklace Creeper	
Chamidae	*Chama fibula*	Jewel-box Clam	
Columbellidae	*Mitrella essingtonensis*	Port Essington Dove Snail	P25430
Corbulidae	*Serracorbula coxi*	Basket Clam	P25431
Dialidae	*Diala* sp.	Diala Snail	P27701
Glauconomidae	*Glauconome plankta*	Sea-green Mussel	P25716
Haminoeidae	*Atys subtortuosus*	Bubble Snail	P25719
Ischnochitonidae	*Particulazona milnei*	Milne's Chiton	P26761
Isognomonidae	*Isognomon nucleus*	Mangrove Clam	P31184
Lottiidae	*Patelloida cryptalirata*	Owl Limpet	P25645
Mytilidae	*Brachidontes maritimus*	Scorched Mussel	P31185
Mytilidae	*Musculus miranda*	Miranda Nesting Mussel	P26986
Nassariidae	*Nassarius dorsatus*	Dog Whelk	
Nassariidae	*Nassarius fraudator*	Mangrove Dog Whelk	P12459
Ostreidae	*Booneostrea cucullina*	Rock Oyster	P31183
Potamididae	*Cerithideopsilla cingulata*	Mud Creeper	P25429
Potamididae	*Telescopium telescopium*	Longbum	
Potamididae	*Terebralia palustris*	Lesser Longbum	P26320
Potamididae	*Terebralia semistriata*	Lesser Longbum	P29952
Cylichnidae	*Tornatina* sp.	Bubble Snail	P25458
Stenothyridae	*Stenothyra* sp.	Stenothyra Snail	P27702
Tellinidae	*Tellina capsoides*	Wafer Clam	P3916
Tellinidae	*Tellina iridescens*	Pink Slender Wafer Clam	P25435
Trapezidae	*Trapezium sublaevigatum*	Square Clam	P26859
Trochidae	*Austrocochlea diminuta*	Top Snail	P25457
Trochidae	*Calthalotia mundula*	Top Snail	P25427
Veneridae	*Circe australis*	Venus Clam	P24166
Veneridae	*Gafrarium tumidum*	Swollen Venus Clam	P25715
Veneridae	*Marcia hiantina*	Gaping Venus Clam	P26646
Veneridae	*Pitar inconstans*	Pitar Venus Clam	P25434
Veneridae	*Venerupis irus*	Scaley Venus Clam	P26762

Table 3. List of polychaetes (Annelida: Polychaeta) from Lake Alexander		
(All the species except *Hydroides* sp. were recorded during the present survey)		
Family	**Scientific Name**	**MAGNT Voucher**
Capitellidae	*Mediomastus* sp.	W19342
Eunicidae	*Palola* sp.	W19343
Lumbrineridae	*Abyssoninoe* sp.	W19344
Maldanidae	*Praxillella* sp. 1	W19345
Maldanidae	*Praxillella* sp. 2	W19346
Nereididae	*Solomononereis marauensis*	W19347
Nereididae	*Perinereis vancaurica*	W19348
Nereididae	*Neanthes bongcoi*	W19349
Oenonidae	*Oenone* sp.	W19350
Orbiniidae	*Leitoscoloplos* sp.	W19351
Orbiniidae	*Leodamas australiensis*	W19352
Pilargidae	*Sigambra* sp.	W19353
Polynoidae	*Paralepidonotus ampulliferus*	W19354
Polynoidae	*Lepidonotus* sp.	W19355
Serpulidae	*Hydroides sanctaecrucis*	W19356
Serpulidae	*Hydroides* sp.	W19359
Serpulidae	*Pomatoleios* sp.	W19357
Spionidae	*Polydora* sp.	W19360
Syllidae	*Eusyllis* sp.	W19361
Terebellidae	*Loimia ingens*	W19363
Terebellidae	*Thelepus robustus*	W19369

Table 4. Other fauna (arranged in phylogenetic order) from Lake Alexander			
(All the species in this table were recorded during the present survey)			
Family	**Scientific Name**	**Common Name**	**MAGNT Voucher**
CNIDARIA: SCYPHOZOA		**Jellyfish**	
Cassiopeidae	*Cassiopea* sp.	Upside-down Jellyfish	C12337
ARTHROPODA: CRUSTACEA		**Crustaceans**	
Alpheiadae	*Alpheus euphrosyne*	Pistol Shrimp	Cr14218
Diogenidae	*Clibanarius longitarsus*	Marine Hermit Crab	Cr14217
ARTHROPODA: INSECTA		**Insects**	
Leptopodididae	?	Water Bug	
ECHINODERMATA: OPHIUROIDEA		**Brittle Starfish**	
Amphiuridae	*Amphiura* sp.	Brittle Starfish	
VERTEBRATA: AVES		**Birds**	
Anatinidae	*Tadorna radjah*	Burdekin Duck	
Ardeidae	*Butorides striatus*	Mangrove Heron	
Charadriidae	*Charadrius mongolus*	Mongolian Sandplover	
Charadriidae	*Vanellus miles*	Masked Lapwing	
Laridae	*Larus novaehollandiae*	Silver Gull	
Scoloplacidae	*Tringa hypoleucos*	Common Sandpiper	

Appendices

Appendix 1. Raw data for molluscs for March 2004

Taxon ↓ Location →	1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	6.1	6.2	6.3	6.4	6.5	7.1	7.2	7.3	7.4
Pugilina cochlidium	Due to an uncontrolable error, there was no sampling conducted on these zones during the march period.											No live specimens found			No live specimens found	No live specimens found			No live specimens found									
Cerithium coralium								60	25	23			4							12	17	17	3	3	20	20	5	4
Clypeomorus bifasciata																												
Chama fibula																												
Mitrella essingtonensis								2																				
Serracorbula coxi																												
Diala sp.																												
Glauconome plankta																												
Atys subtortuosus																												
Particulazona milnei																												
Patelloida cryptalirata																												
Brachidontes maritimus																												
Musculus miranda																												
Nassarius dorsatus																												
Nassarius fraudator																												
Saccostrea cucullata																												
Cerithideopsilla cingulata								5	12				3				2			18	17				12	12		
Telescopium telescopium																												
Terebralia palustris																												
Tornatina sp.																												
Stenothyra sp.																												
Tellina capsoides																												
Tellina iridescens									2	3							4											
Trapezium sublaevigatum																												
Austrocochlea diminuta								2																	5			
Calthalotia mundula																									5			
Circe australis										8	4			1			5	3		2	4	4				4	5	
Gafrarium tumidum														3							1							
Marcia hiantina																												
Pitar inconstans																					1							2
Venerupis irus																												

Appendix 2. Raw data for molluscs for April 2004

Taxon ↓ Location →	1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	6.1	6.2	6.3	6.4	6.5	7.1	7.2	7.3	7.4
Pugilina cochlidium																												
Cerithium coralium				4	21	12	5	2	31					3					12		6	13				17	4	3
Clypeomorus bifasciata																												
Chama fibula	5	1																										
Mitrella essingtonensis																												
Serracorbula coxi													2															
Diala sp.																												
Glauconome plankta			1																									
Atys subtortuosus																												
Particulazona milnei	1																											
Patelloida cryptalirata																												
Brachidontes maritimus																												
Musculus miranda																												
Nassarius dorsatus																												
Nassarius fraudator																												
Saccostrea cucullata																												
Cerithideopsilla cingulata		8	5	4	42		7	2	17	3									3	13	7				13	9	1	
Telescopium telescopium																												
Terebralia palustris																												
Tornatina sp.																												
Stenothyra sp.																												
Tellina capsoides																							1					
Tellina iridescens		9		2		1			1				1				2											
Trapezium sublaevigatum		1																										
Austrocochlea diminuta	3	12							3											1						3		
Calthalotia mundula	1	9																		1						1		
Circe australis	114	121		5		1			2	3	3		6	5			5	2	3	3	3	2	4			7	1	
Gafrarium tumidum	1	3		1									2										1					
Marcia hiantina																												
Pitar inconstans				1							1																	
Venerupis irus																												

No live specimens found

Appendix 3. Raw data for molluscs for May 2004

Taxon ↓ Location →	1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	6.1	6.2	6.3	6.4	6.5	7.1	7.2	7.3	7.4
Pugilina cochlidium				No live specimens found											No live specimens found	No live specimens found						No live specimens found		No live specimens found				
Cerithium coralium					10	16	9	26	12	25		1					3			1	17				1	18	6	4
Clypeomorus bifasciata												1																
Chama fibula		30	16																									
Mitrella essingtonensis																										1		
Serracorbula coxi																												
Diala sp.																												
Glauconome plankta																												
Atys subtortuosus																												
Particulazona milnei																												
Patelloida cryptalirata																												
Brachidontes maritimus		63																										
Musculus miranda																												
Nassarius dorsatus																												
Nassarius fraudator																												
Saccostrea cucullata																												
Cerithideopsilla cingulata	63	12	12		23	8	18	33	7	26		1	11				2			8					3	12	5	
Telescopium telescopium																												
Terebralia palustris																												
Tornatina sp.																												
Stenothyra sp.																												
Tellina capsoides																												
Tellina iridescens	2	2						3	1	1		1	1	2			1			1	3							
Trapezium sublaevigatum		4																										
Austrocochlea diminuta	2	4							1				2															
Calthalotia mundula	1	2						2													1							
Circe australis		111	5		5	1		1	5	2	12		8	3			5	2	1		22		6			3	2	
Gafrarium tumidum		1							1		3		1	2			3											
Marcia hiantina		2			1																							
Pitar inconstans	1	1	1								3										1						1	
Venerupis irus		8																										

Appendix 4. Raw data for fishes for April 2004

Taxon ↓ Location →	Zone 1	zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Boat ramp
Ambassis nalua	4					1	None found	
Ambassis vachellii		79	2					
Cryptocentroides insignis	1							
Drombus globiceps				8	13	1		1
Herklotsichthys gotoi		2	1					
Herklotsichthys lippa		3	5					
Pseudogobius sp.2	2			3	1			